JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1979, 31, 299-306 NUMBER 3 (MAY)

RAT DEFENSIVE BEHAVIOR: BURYING NOXIOUS FOOD[1]

DONALD M. WILKIE, A. JOHN MACLENNAN, AND JOHN P. J. PINEL

THE UNIVERSITY OF BRITISH COLUMBIA

In Experiment 1, rats living in chambers containing bedding material were injected with a toxicosis-producing dose of lithium chloride shortly after their initial taste of sweetened condensed milk. They consumed no additional milk and used the bedding to bury the spout through which the milk had been delivered, although they did not bury a concurrently available water spout. In another control condition, rats did not bury a spout containing a novel solution (saccharin) not paired with toxicosis. In Experiment 2, rats did not bury a milk spout until milk consumption was followed by toxicosis. In Experiment 3, rats buried a spout containing Tabasco pepper sauce but not a concurrently available water spout. Thus, burying the food source appears to be an integral component of the rat's defensive reaction to noxious food.

Key words: naturalistic environment, defensive repertoire, burying, taste aversion, rats

---

Knowledge of an animal's behavioral repertoire can provide the basis for major insights into its performance in laboratory learning experiments (cf. Dunham, 1971; Shettleworth, 1975). For example, Bolles (1970) has argued that the speed with which a rat acquires an avoidance response depends on how closely this response resembles the fleeing, freezing, or aggressive responses that comprise the rat's defensive repertoire.

Although research has substantiated Bolles' view that fleeing, freezing, and aggressive behavior are, in fact, ways in which rats respond to aversive stimulation (e.g., Blanchard & Blanchard, 1971; Blanchard, Blanchard, & Takahaski, 1977; Blanchard, Fukanaga, & Blanchard, 1976; Bronstein & Hirsch, 1976), recent studies (Pinel & Treit, 1978; Pinel, Treit, & Wilkie, Note 1) show that the defensive repertoire of the rat is not limited to these three alternatives. In these studies, rats shocked once through a wire-wrapped wooden dowel mounted on a wall of a test chamber did not flee, freeze, or fight; they returned to the dowel and buried it with bedding material from the floor of the chamber. The rats approached the dowel, pushing and spraying the bedding material ahead with snout and forepaws. Moreover, pairing of the dowel with shock was critical in directing the burying. Rats buried the shock-correlated dowel but not an identical one located on the opposite wall.

EXPERIMENT 1

The objective of the present study was to determine whether rats would bury conditioned aversive stimuli other than those paired with local electric shock. More specifically, the purpose was to demonstrate that rats will bury the source of a novel solution paired with toxicosis. Because defensive burying by rats had not been reported in response to aversive stimuli other than electric shock, its demonstration in a taste-aversion paradigm (Garcia, Hankins, & Rusiniak, 1974) was a major step in establishing the generality of the response. Moreover, it provided support for the view (Pinel & Treit, 1978) that burying is an important defensive response in the rat's natural environment.

METHOD

Subjects

Five 450- to 600-g experimentally naive male hooded rats (Canadian Breeding Farm and Laboratories, La Prairie, Quebec) served as subjects.

---

[1]Supported by National Research Council of Canada Grant A8353 and University of British Columbia Natural, Applied, and Health Sciences Grant 9614. F. LePiane, D. Treit, and J. Fedorick made valuable contributions to this research. Send reprint requests to Donald M. Wilkie, Department of Psychology, The University of British Columbia, Vancouver, B.C., Canada V6T 1W5.

Baseline Conditions

The experiment began by transferring the rats from individual stainless steel mesh cages to 43- by 38- by 25-cm test chambers, where they remained under controlled illumination (12 hr light/dark) for the duration of the experiment. Except for the transparent lids, the chambers were constructed of wood. The floor of each chamber was covered with about 4 cm of San-i-cel, a bedding material of ground corn cob (Paxton Processing Co., Paxton, Illinois). Purina Laboratory Chow was available continuously throughout the experiment. Each subject was handled occasionally prior to conditioning and testing.

The stainless steel spouts (.7 cm in diameter) of two graduated bottles were inserted through holes located 7 cm above the floor (3 cm above the bedding) in opposite corners so that they protruded 4 cm into each chamber at a slight downward angle. Initially, each rat was provided with continuous access to these two bottles filled with water for at least 7 days. Then access to the bottles was limited to the same 1-hr period each day for at least 4 days.

Conditioning

On the conditioning day, a solution of Borden's sweetened condensed milk, mixed 1:1 (vol/vol) with tap water, was presented to each rat for 30 min during the usual drinking period through one (randomly selected) of the two spouts. No water was available during this 30-min period. In contrast to the bare stainless steel water spout, the milk spout had .5-cm stripes of black electrical tape. After 30-min access to the milk, each rat was removed from the chamber, immediately injected intraperitoneally with 10 cc of a .64% lithium chloride (LiCl) solution, and placed in a Plexiglas holding cage for 5 min.

Test Phase

While each rat was in the holding cage, the bedding material within 10 cm of each spout hole was distributed evenly at a height of 4 cm by the experimenter. Then each rat was placed in its chamber, facing one of the two corners that did not contain a spout hole. The striped milk spout was still available in its original position, and 1 min later the plain spout of the water bottle was inserted through the other hole.

The height of bedding material at the point at which both the milk and water spouts entered the box was recorded about a dozen times by the experimenter or by an automated video recorder during the 24 hr (42 hr for Rat 3) after the LiCl injection. Cumulative consumption from the water and milk bottles was recorded 2 hr and again 24 hr (42 hr for Rat 3) after the LiCl injection.

Control Procedure

Approximately 24 hr following the completion of the first 24-hr test, the bedding material in the chambers was leveled by the experimenter and the 23-hr water-deprivation schedule reinstated for Rats 2, 4, and 5. After the three rats had been maintained on the deprivation schedule for at least 2 days, the bedding material was leveled again, and a .2% (wt/vol) saccharin solution was made available from a striped spout through the same spout hole from which milk had previously been available. The spout of the water bottle was inserted through the other hole. Saccharin and water consumption as well as the accumulation of bedding material were recorded over the ensuing 24-hr period as before.

Results

A conditioned aversion to milk was established in all five rats. Although each rat drank substantial amounts of milk in the 30-min period before poisoning, they did not consume measurable amounts during the ensuing 24-hr period (see Table 1). In contrast, substantial volumes of water were consumed during the test. Moreover, every rat deposited substantially more bedding at the milk spout than at the water spout (Figure 1). In fact, only one rat failed to cover the milk spout completely with the bedding. Rat 5 deposited the bedding material more in front of the spout than did the other rats, and as a result the milk spout remained exposed where it entered the box although the tip itself was covered (see unconnected points, Figure 1). Rat 5 was also the only subject that did not remove some of the bedding from beneath the water spout during the test.

The topography of the burying behavior generally resembled that observed when rats bury well-defined sources of electric shock (cf. Pinel & Treit, 1978). The rats repeatedly moved toward the milk spout, spraying the

Table 1

Fluid Intake (ml) in Experiment 1

Rat	Water		Milk (poisoned)		
	2 hr after LiCl	24 hr after LiCl	.5 hr before LiCl	2 hr after LiCl	24 hr after LiCl
1	15	55	6	0	0
2	10	35	8	0	0
3	10	50[a]	9	0	0[a]
4	10	40	3	0	0
5	10	50	4	0	0

[a]42 hr after LiCl.

bedding ahead with shoveling movements of the snout and rapid pushing movements of the alternating forepaws.

Two rats (3 & 5) eventually removed some of the bedding material that they had accumulated over the milk spout.

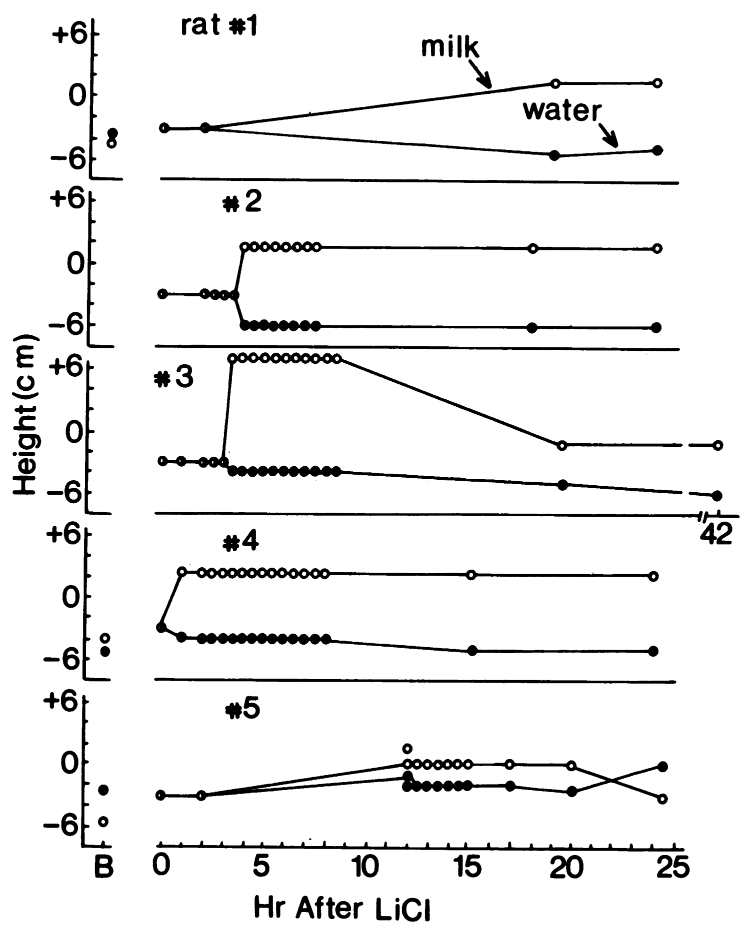

Fig. 1. Height of bedding material deposited at the water and milk spouts at various times after injection of LiCl. Height scores are cm above (+) or below (−) point at which spout entered box. Points above B are averages of the height of material at the two spouts during the last 7 baseline days. (These data were not collected for Rats 2 and 3). Points above 0 hr were determined by the experimenter's leveling of the bedding, not by the behavior of the rat. A video recorder malfunction resulted in the loss of several observations for Rat 1. For Rat 5 a measurement of the height of material at the tip of the spouts 12 hr after the LiCl injection is indicated by the unconnected points.

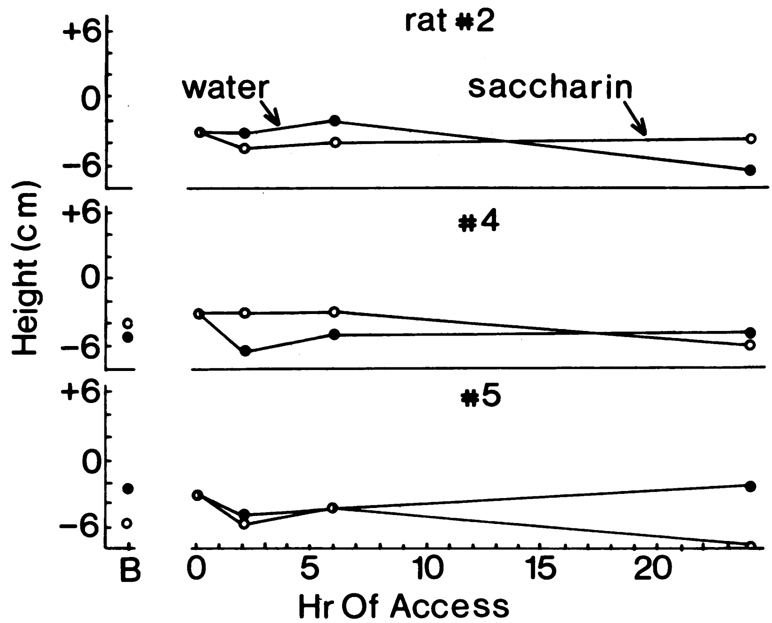

Fig. 2. Height of bedding material deposited at the water spout and at the saccharin spout at various times after their introduction. Other details are as in Figure 1.

The results of the second test are presented in Figure 2. When consumption of a novel solution (i.e., saccharin) was not followed by an injection of LiCl, no subject accumulated bedding around the novel-solution spout. Rats 2, 4, and 5 drank 50, 40, and 50 ml of saccharin during the 24-hr test period. Water intakes in this period were 30, 33, and 50 ml.

EXPERIMENT 2

In Experiment 1, rats buried a milk spout after the consumption of a novel milk solution had been followed by toxicosis, but they did not bury a water spout or the source of a novel saccharin solution that had not been paired with toxic effects. Although these results suggested that the burying was being directed by the pairing of the milk spout with the toxicosis, they did not rule out the possibility that the burying resulted from a tendency to bury objects paired with the flavor of the milk solution. Thus, in Experiment 2 the responses of rats to "poisoned" and "unpoisoned" milk solutions were compared directly.

METHOD

Subjects

The subjects were three 350- to 400-g male hooded rats housed and maintained up to the end of the baseline period as in Experiment 1.

Unpoisoned-Milk Test

After 30 min of access to the milk solution in the striped spout, each rat was removed from the test chamber. The experimenter leveled the bedding and 5 min later returned each rat to begin the 24-hr test period.

Poisoned-Milk Test

At the end of the 24-hr test period, both water and milk bottles were removed. The above sequence of events was repeated 24 hr later except that this time LiCl was injected after the 30-min period of access. Rats 6 and 8 then were observed for 24 hr. The third rat (7) started to drink milk about 20 hr after the LiCl injection. Consequently, the observation period was extended for this subject. Then it was deprived for another 24 hr, and another milk-LiCl pairing was administered before a subsequent 24-hr test period.

RESULTS

Fluid intake during the unpoisoned-milk and poisoned-milk tests are shown in Table 2. As in Experiment 1, a conditioned aversion to milk clearly was established, although for Rat 7 two milk-LiCl pairings were necessary. (The

Table 2

Fluid Intake (ml) in Experiment 2

	Unpoisoned-Milk Phase				
	Water		*Milk (unpoisoned)*		
Rat	*2 hr after return to chamber*	*24 hr after return to chamber*	*.5 hr before removal*	*2 hr after return to chamber*	*24 hr after return to chamber*
6	24	42	10	5	20
7	16	60	9	1	23
8	26	60	5	4	38
	Poisoned-Milk Phase				
	Water		*Milk (poisoned)*		
	2 hr after LiCl	*24 hr after LiCl*	*.5 hr before LiCl*	*2 hr after LiCl*	*24 hr after LiCl*
6	8	45	10	1	1
7	5(5)[a]	60(60)[a]	10(4)[a]	0(0)[a]	3[b](0)[a]
8	50	74	9	0	0

[a]Measures in parentheses were taken after the second milk-LiCl pairing.
[b]This rat drank another 27 ml of milk shortly after the completion of the first 24-hr test.

failure to produce a more complete conditioned milk aversion in Rat 7 after its second exposure to the milk solution was followed by toxicosis may have been due partly to the fact that by the second phase of the experiment the milk solution was no longer novel. Food-aversion learning progresses most rapidly when toxicosis follows consumption of novel foods [e.g., Kalat, 1974].)

Figure 3 shows the height of bedding material deposited at the milk and water spouts when milk was not paired with LiCl (top panel for each rat) and when milk was paired with LiCl (bottom panel for each rat). As in Experiment 1, when the consumption of the milk solution was followed by toxicosis, the rats accumulated a higher pile of bedding material at the milk spout than at the water spout. However, when milk intake was not paired with poisoning, the milk spout was never buried. Thus, it seems that pairing of milk spout and toxicosis was the critical factor in eliciting burying. The results for Rat 7 illustrate this point. This rat did not bury the milk spout when milk consumption was not followed by toxicosis or after the first injection of LiCl after which it continued to drink milk (values not in parentheses, Table 2); however, it did bury the milk spout after the second milk-LiCl pairing after which it did not drink milk (values in parentheses, Table 2).

All three rats eventually removed at least some of bedding material they had accumulated at the poisoned milk spout, but only Rats 7 and 8 uncovered the spout. Rat 8 subsequently reburied it.

EXPERIMENT 3

The results of Experiments 1 and 2 established that rats will bury the source of a novel flavor that has been paired with toxicosis. Experiment 3 determined whether LiCl poisoning was necessary for eliciting such burying or whether rats would bury the source of a solution with an inherently aversive taste.

Method

Subjects

The subjects were four 350- to 400-g male hooded rats housed and maintained up to the end of the baseline period as in Experiment 1.

Procedure

The bedding material on the floor of the test chamber was leveled by the experimenter, and then the rats were presented with an unmarked water spout and a striped spout containing undiluted Tabasco pepper sauce. The rats were observed for 24 hr.

Results

Each rat consumed a small volume of Tabasco sauce and a much larger volume of water during the 24-hr test (see Table 3). Furthermore, all four rats accumulated more bed-

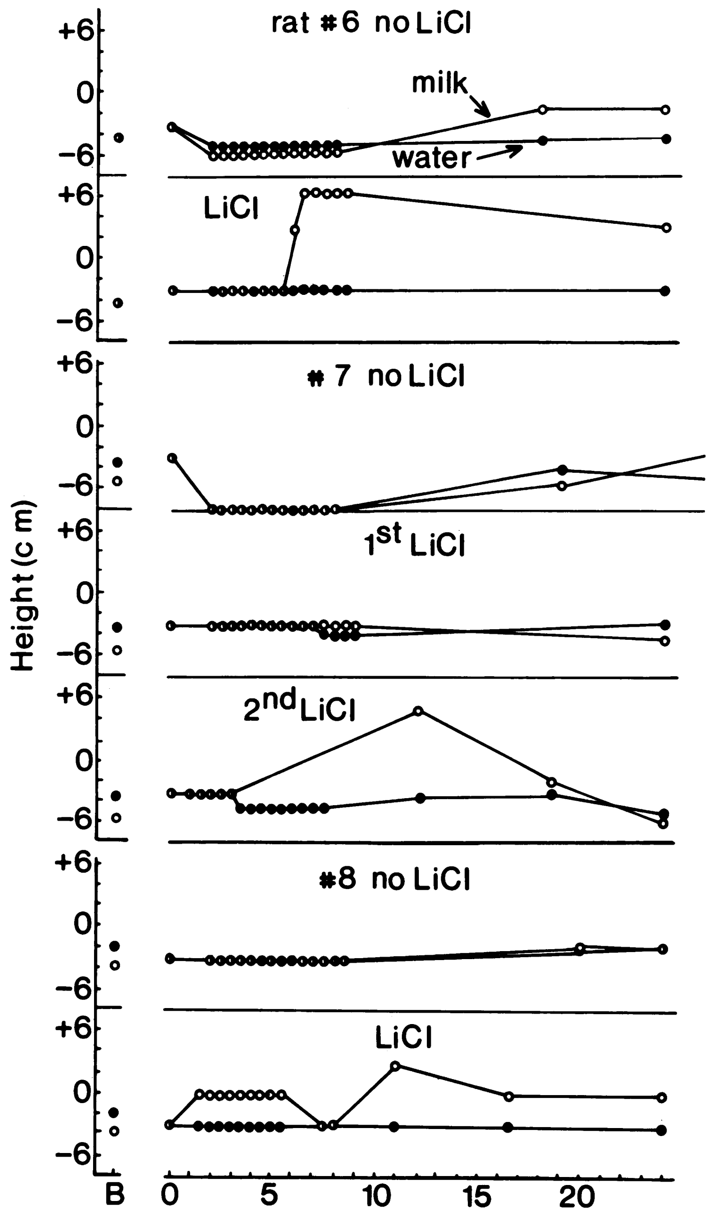

Fig. 3. Height of bedding material deposited at the milk and water spouts at various times after rats were returned to their test chambers. The top panel for each rat illustrates the accumulation of bedding when milk was not followed by LiCl. The results of the tests following LiCl administration are presented in the lower panels. A few measurements for Rats 7 and 8 were unavailable because of technical problems (e.g., rat sitting over spout). Other details are as in Figure 1.

ding material at the Tabasco spout than at the water spout (see Figure 4).

DISCUSSION

Bolles (1970) suggested that the reactions of rats to aversive stimuli are limited to flight, freezing, and aggression; however, in the recent study of Pinel & Treit (1978) rats buried a well-defined source of electric shock even when the shock-test interval was as long as 20 days. The present observations of rats burying noxious food show that burying occurs in response to aversive stimuli other than local-

Table 3

Fluid Intake (ml) in Experiment 3

Rat	*Water*		*Tabasco*	
	After 1 hr	*After 24 hr*	*After 1 hr*	*After 24 hr*
9	*	*	2.0	4.0
10	20	60	.5	2.5
11	41	103	.5	2.5
12	22	72	.5	5.0

*Exact data unavailable; values within range of other rats.

ized electric shock. In the first two experiments, every rat pushed bedding material toward a spout containing a novel milk solution previously paired with toxicosis; in Experiment 3, each rat accumulated bedding around the Tabasco spout, presumably because of its aversive taste.

Rats have been observed to bury noxious food at least once before. Rzoska's (1954) description of the behavior of rats to poisoned bait included the following statement: "The rats turned their heads away when bait was brought near them, some pushed it aside with their forepaws or grasped it fiercely, dropped it, or buried it in the litter. Sometimes they attacked the bait stick" (p. 387). Since rats in taste aversion experiments are usually tested in barren chambers with grid or mesh floors, the paucity of such descriptions is not surprising.

In the present experiments, rats did not bury spouts that were not paired with toxicosis or noxious tastes. Rats did not bury sources of novel solutions in Experiments 1 (saccharin) and 2 (sweetened condensed milk) when consumption was not followed by LiCl. Moreover, in each of the three experiments, each rat deposited bedding material at the spout paired with the aversive fluid but not at the concurrently available water spout. The latter observation parallels the results of Pinel and Treit (1978). They found that rats shocked by one of two identical dowels buried only the dowel paired with shock.

During the 24-hr test period, some rats uncovered aversive solutions that they previously had buried. We do not know if the rats "deliberately" uncovered the spout or simply did not rebury an "accidentally" uncovered spout. Although rats burying sources of elec-

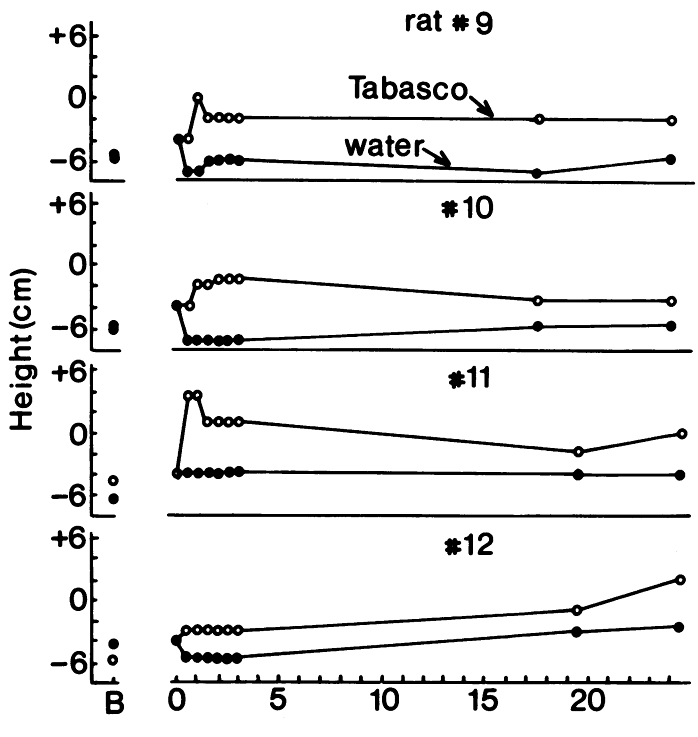

Fig. 4. Height of bedding material deposited at the Tabasco and water spouts at various times after their introduction. Other details as in Figure 1.

tric shock have not subsequently uncovered them, it is not clear whether this is attributable to the brevity of the tests or to some inherent difference in the effect of electric shock and toxicosis on burying.

Given that rats learn quickly to avoid drinking an aversive solution, an interesting question arises as to why they should also bury it. There appear to be three approaches to this question. One possibility is that burying is reinforced by the reduction of conditioned aversive stimuli (perhaps visual and odor cues associated with the aversive solution). However, although negative reinforcement might explain why burying, once initiated, would continue, it cannot account for the first burying sequence of each rat. Another possibility is that burying occurs through some transfer process. A problem with this approach, however, is that it is difficult to imagine the circumstances under which laboratory rats would learn burying-like behaviors. The third approach emphasizes phylogeny. It seems possible that burying is an "innate defensive reaction." If one grants this possibility, the question still arises as to why a rat will bury aversive solution that it is not going to consume. Perhaps burying is an inherited "altruistic" reaction with a status similar to danger-warning calls of certain species. In any event, phylogeny does not account totally for burying behavior. Conditioned aversive stimuli can play a major role, if not in eliciting or releasing burying, at least in directing it.

REFERENCE NOTE

1. Pinel, J. P. J., Treit, D., and Wilkie, D. M. *Constraints on avoidance learning: Burying an unfounded assumption.* Invited paper, Northeastern Regional Meeting of the Animal Behavior Society, St. John's, Newfoundland, October 1977.

REFERENCES

Blanchard, R. J., & Blanchard, D. C. Defensive reactions in the albino rat. *Learning and Motivation*, 1971, **2**, 351-362.

Blanchard, R. J., Blanchard, D. C., & Takahashi, L. K. Reflexive fighting in the albino rat: Aggressive or defensive behavior? *Aggressive Behavior*, 1977, **3**, 145-155.

Blanchard, R. J., Fukunaga, K. K., & Blanchard, D. C. Environmental control of defensive reactions to a cat. *Bulletin of the Psychonomic Society*, 1976, **8**, 179-181.

Bolles, R. C. Species-specific defense reactions and avoidance learning. *Psychological Review*, 1970, **77**, 32-48.

Bronstein, P. M., & Hirsch, S. M. Ontogeny of defensive reactions in Norway rats. *Journal of Comparative and Physiological Psychology*, 1976, **90**, 620-629.

Dunham, P. J. Punishment: Method and theory. *Psychological Review*, 1971, **78**, 58-70.

Garcia, J., Hankins, W. C., & Rusiniak, K. W. Behavioral regulation of the milieu interne in man and rats. *Science*, 1974, **185**, 824-831.

Kalat, J. W. Taste salience depends on novelty, not concentration, in taste-aversion learning in the rat. *Journal of Comparative and Physiological Psychology*, 1974, **86**, 47-50.

Pinel, J. P. J., & Treit, D. Burying as a defensive response in rats. *Journal of Comparative and Physiological Psychology*, 1978, **92**, 708-712.

Rzoska, J. The behaviour of white rats towards poison baits. In D. Chitty (Ed.), *Control of rats and mice* (Vol. 2) London: Oxford University Press, 1954.

Shettleworth, S. J. Reinforcement and the organization of behavior in golden hamsters: Hunger, environment, and food reinforcement. *Journal of Experimental Psychology: Animal Behavior Processes*, 1975, **1**, 56-87.

Received October 31, 1978
Final acceptance December 20, 1978